PROJECT COMMITMENT DOCUMENT

Data Services

Goddard Space Flight Center

Demand Access System (DAS) Development and Deployment

It is the responsibility of each of the signing parties to notify the other in the event that a commitment cannot be met, and to initiate a timely renegotiating of the terms of this agreement.

AGREEMENTS **DATE**

Original Signed By: *2/22/00*

______________________________ __________

Thomas A. Gitlin
DAS Product Manager

Original Signed By: *3/2/00*

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Stan C. Newberry
Director, Space Operations

CONCURRENCE

Original Signed By: *3/2/00*

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Patrick M. Duffin
Mission and Data Services Upgrades Project Manager

1.0 PROJECT NEED STATEMENT

A) Program/Project New Capability Requirement Approved by Program/Project Manager

1. Capability to be developed and supporting requirements.

This PCD calls for the design, development, installation and testing of a system that will provide the infrastructure to greatly expand existing TDRSS Multiple Access Return (MAR) capabilities at a relatively low cost. This new capability is called the Demand Access System (DAS). This effort proposes to leverage on the investments already made in DAS technology development and in the Third Generation Beamforming System.

Background

All six existing Tracking and Data Relay Satellites (TDRSs) possess on-board phased array antenna systems. These antenna systems provide communication service to customers by using ground-based electronics to process the TDRS antenna signals emanating from customers. Each ground-based hardware processing system is termed a Multiple Access (MA) system, and each processes customer ephemeris to dynamically form beams on the customer. Each TDRS requires a dedicated MA system to provide MA services.

Currently, each of the four White Sands Complex MA systems can accommodate a maximum of six individual return links. The Guam Remote Ground Terminal can accommodate two. These limitations constrain the flexibility and applicability of the MA return link systems, and limit the number of customers that can simultaneously utilize MA return services.

NASA intends to pursue space-based investigation in the future with use of "faster, better and cheaper" spacecraft. These spacecraft will require unique communication capabilities. The Space Network (SN) is strategically positioned to be an efficient service provider to this class of customers. Since higher capacity and lower cost services will be available with the implementation of DAS, the market for use by NASA, other government agencies, and other organizations will logically expand. Additionally, customers have expressed strong desires to use dedicated, 24x7 links for receiving telemetry data to enable rapid re-pointing of instruments for observation of cosmic and earth-based events. The DAS will enable innovative new types of services, and allow more straightforward expansion of ground-based capabilities.

Concepts exist for space-based investigations using multiple spacecraft flying in formations. The DAS can be an efficient communication solution for this class of customer. The demands of a single multiple-emitter customer could quickly exceed the current capacity of the current MAR system. With the implementation of DAS, the SN will be positioned to allow significant expansion capability at relatively low costs.

Expected/Projected Customer Base

A DAS Business Consideration document has been developed and details three examples of the class of customers the DAS is designed to attract and support. The Business Consideration is based on mission concepts that use clustered (formation flying) and/or co-located emitters. The current MA system is unable to support these classes of customers.

The SWIFT Gamma Ray Burst Explorer implementation was awarded in October 1999. The SWIFT spacecraft, which is expected to launch in 2003, will detect gamma-ray bursts in real-time and will downlink celestial coordinates within 15 seconds to a ground based network for observation. SWIFT has baselined a full-period 24x7 MA return link as a mission support requirement. DAS is an ideal solution for SWIFT downlink support.

The Earth Observing System (EOS) desires a 24x7 return link for monitoring for spacecraft emergencies and has also expressed interest in using DAS services as one piece of a future spacecraft-to-spacecraft communication conduit. A demonstration of DAS capabilities to EOS is planned for early CY00.

The Gamma Ray Large Area Space Telescope (GLAST) project, which has a projected launch in CY05, has also expressed interest in the new capabilities DAS will provide. As with SWIFT, a continuous downlink is critical to meet the mission science objectives.

Several other external organizations, such as the National Naval Ice Center, have expressed great interest in the capabilities of DAS.

Current Status of DAS Technology Efforts

Figure 1 - An Element Multiplexer Correlator

Figure 2 - An Individual Beamforming Unit Group populated with six beamformers

A technology development effort, begun in 1994, proved that compact, low cost ground based MAR beamformers can be built. The technology effort demonstrated that TDRS MAR services can be greatly expanded at a relatively low cost, and that these services could be provided on a demand basis rather than on a pre-scheduled basis; hence the term DAS.

The technology development effort led to a production contract award to Stanford Telecommunications (STel) for the construction and deployment of Element Multiplexer Correlators (EMCs) into each of the MA capable SGLTs at the WSC, including the Guam Remote Ground Terminal (GRGT). This deployment effort, called the Third Generation Beamforming System (TGBFS) was approved via a PCD in February 1999. The effort described in the TGBFS PCD will result in the delivery of 5 operational EMCs and a single pre-production Individual Beamforming Unit Group (IBUG) populated with six beamformers. System spares, documentation and training to CSOC operations and maintenance personnel will be provided as part of the TGBFS effort.

The DAS effort described in this PCD will serve to build on the TGBFS effort by adding global system control and coordination functions and data distribution capabilities.

TGBFS Components

The TGBFS consists of two principal components, the EMC and the IBUG. Both units are controlled via common Personal Computers (PCs).

The EMC is a single chassis [Figure 1] that passively connects to an existing MA analog-to-digital quad splitter. The quad splitter provides TDRS array antenna signals to the EMC, which in turn provides the data to Individual Beamforming Unit Groups (IBUGs) [Figure 2]. Each EMC can drive up to eleven IBUGs without modification. Expansion beyond eleven outputs is fairly straightforward.

IBUGs are a result of the same successful technology effort described above, however, only one pre-production model was fabricated as a deliverable under the TGBFS effort. The IBUG is modularly expandable and can contain up to six independent beamformers within a single chassis. Each beamformer within an IBUG is a low-cost, one circuit card assembly. Each beamformer processes data fed to it by the EMC and provides both digital and intermediate frequency outputs which can be connected to receivers. IBUGs are considered COTS items.

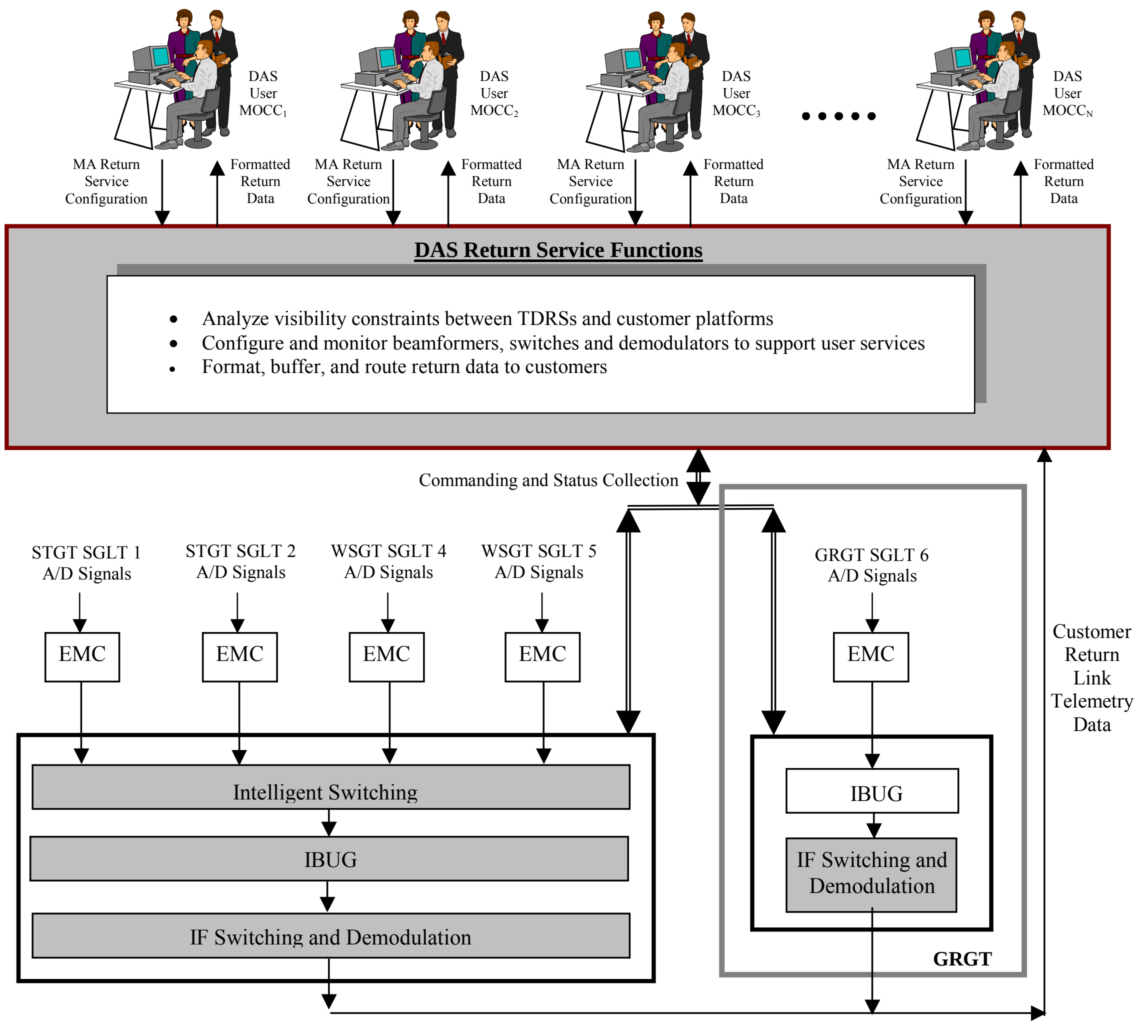

Figure 3 - DAS Return Service Functional Architecture (shaded components are new DAS items/functions)

DAS High Level Requirements

A reference DAS architecture is shown in Figure 3. The architecture shown pools IBUGs to allow sharing between SGLTs. Specifics of the architecture will probably vary somewhat from Figure 3 as detailed system design progresses.

For the new services enabled by DAS, the DAS shall:

a. Provide the capability for continuous, conflict-free, DAS MA return link services 24 hours per day, 7 days per week upon demand from customers.
b. Provide an automated capability to transition DAS customer services between TDRSs/SGLTs.
c. Provide the capability to support multiple, independent Multiple Access (MA) return links per TDRS/SGLT/Ground Station.
d. Meet or exceed the current communications performance and capabilities of the existing MA return link with the exceptions of the functions not possible due to the lack of tie-ins with the MA forward link (such as coherent support, cross-support, return channel time delay, range zero set, etc.)
e. Provide demodulation and data distribution capabilities for each DAS MAR data service.
f. Automate the operation of all DAS return link services.

g. Provide COTS data and control interfaces for DAS customers with the flexibility of accommodating non-standard/customer-unique telemetry interfaces (e.g. use of dedicated T1s and/or fiber).
h. Provide simple, low cost, modular expansion capabilities to facilitate the addition of DAS return link channels as needs change.

2. Why current capabilities cannot meet these requirements.

New and current NASA enterprise customers have expressed needs for:

a) **Immediate access to services.** Current services must be scheduled in advance of use. Existing NCC/WSC scheduling processes nominally call for support schedules to be submitted up to 21 days in advance of the desired support. There is a capability to schedule service several minutes prior to the desired support time, however, the process generally involves several human operators, and does not provide *immediate* access. Customers have indicated that *immediate* access to services is highly desirable from both a science and spacecraft safety perspective. The capability for "Save-our-Ship" (SOS) transmissions has been expressed as a desirable service. A DAS return link could be configured to monitor a spacecraft 24x7 for signs of trouble.
b) **Extended duration services.** Current systems do not allow services to be scheduled for more than 24 hours without service interruption. Additional service schedules must be transmitted for each 24 hour period.
c) **Simplified scheduling and operation.** The current system requires an interface to the NCC for scheduling and control. Scheduling SN services frequently involves the use of a User Planning System (UPS). New initiatives are being pursued to augment the UPS and to provide web-based scheduling interfaces, both of which will reduce the scheduling complexity for legacy services, but neither method will have the unique capabilities that DAS will provide. For example, the DAS system is envisioned to allow the capability to schedule services that are months and/or years in duration with a single schedule request.
d) **Reduction of service cost**. Advancement of beamformer technology and demodulator technology allow a significant reduction in acquisition cost, and has a high probability of reducing life cycle costs. Both of these factors should serve to reduce service costs. The modular capability of DAS allows expansion as needed when service loading increases.
e) **New Capabilities.** DAS will open an avenue for pursuing the introduction of new service concepts and capabilities with relatively straightforward modifications to the basic DAS system. Some examples of these capabilities are:

- Immediate science alert transmissions from space-based platforms followed by acknowledgement that required resources for support are available.
- A DAS return link could be configured to poll several different spacecraft automatically. A polled spacecraft could indicate the occurrence of an astronomical event and transmit a notification to ground based systems which could then configure another DAS return link immediately for sustained science data transmission.
- Requests for SA service initiated by autonomous customer spacecraft, aircraft, or balloons. A DAS polling link could listen for service requests and configure additional SN services.

3. Alternatives considered

<u>Expansion of existing MA return (legacy) links</u>
The bulk of the legacy MA return link equipment was manufactured by Interstate Electronics Corporation (IEC) and the Telephonics Corporation approximately 10 years ago. The legacy technology is outdated. Each MA system has the inherent capability to handle up to a maximum of 10 schedulable return links, and each is currently populated with 5 (except for Guam, which has 2). Procuring and manufacturing legacy form/fit/function compatible hardware to populate each SGLT would require a significant effort. Estimates from IEC (Oct 1997) for manufacture of Integrated Receivers (demodulators) were approximately $140K per unit; this estimate did not include non-recurring costs nor replacement of obsolescent parts. Non-recurring/obsolescent replacement costs could easily exceed $250K. Additional legacy Adaptive Ground Implemented Phased Array (AGIPA) hardware would be needed to increase the capability of MA capable SGLTs. The updated design and manufacture of additional AGIPAs would exceed $381K per SGLT (based on quotes from Telephonics during the GRO Remote Terminal System effort). Non-recurring costs for new AGIPAs would likely exceed $500K. Changes would be required to both the WSC and the Network Control Center (NCC) software to schedule, monitor and control the expanded MA system equipment, and to provide the new functionality (schedule across multiple SGLTs, etc) that DAS will provide. The software development

effort would be significant. To expand the ground stations to the equivalent service capability DAS is envisioned to provide would cost approximately $5.5M not including the WSC/NCC software modification efforts. Also, the number of equipment racks required for expansion units would pose a challenge. Expansion beyond the 10 links per SGLT would be impractical.

Installation of Customer Unique Equipment

There is precedence in the installation of customer unique communications equipment for support of individual customers. However, pursuing this approach with more than a relatively few number of customers raises significant and difficult questions. From a mission cost standpoint, is the non-recurring and recurring engineering costs of developing and installing equipment affordable for an individual project? Who is responsible for the cost of maintenance of the customer unique equipment located in remote areas? How much physical space is required for the installation? Who is responsible for troubleshooting and resolving operational problems with the unique hardware and software systems when they occur? What is the staffing impact on operational facilities (both the customer facility and WSC/Guam)? How many different customers can be reasonably supported (i.e. when does it become so complicated to support the logistics of maintaining and operating multiple, unique equipments)? What is the overall cost to the project/organization/NASA?

While single-point customer unique solutions are clearly possible, the practicality of this approach would likely become a significant issue if many customers select this approach. The DAS allows uniform, low cost expansion capabilities for which the responsibilities, maintenance and operation are clearly defined.

B) Cost Savings Opportunity(s)

Revenues enabled by DAS would serve to offset implementation cost. A business case is available for review in conjunction with this PCD.

In the era of full cost accounting, overall mission costs must be minimized. An expanded and more efficient SN MA resource has a high probability of reducing operations costs to NASA Enterprise missions.

The new services offered by DAS offer the potential for other types of savings. If the loss of a single spacecraft is avoided once every few years, and/or if unique science data is collected that would otherwise be lost due to the latency of using legacy systems, the implementation costs of DAS would very likely be easily realized above and beyond other cost savings. The reader should note that the SN has been called upon to provide emergency support to malfunctioning spacecraft in the past. The addition of DAS provides an additional tool that could contribute to emergency support.

C) Technology Insertion and Supporting Rationale

A successful DAS implementation will incorporate new technology in miniaturization, advanced beamforming functions, new demodulation functions, new data processing functions, and data distribution functions. Use of COTS where COTS functionality exists would be maximized (e.g. IP routers, switches, etc.)

D) Projected Obsolescence

Based on application of existing technology with its inherent features and capabilities, the projected obsolescence of the DAS equipment is 15 years. The intent of the DAS system is not to wholly replace or affect the obsolescence of existing MA systems, it is to augment and expand the existing MA service capabilities.

E) New Business or Outsourcing Opportunities

The introduction of the DAS will establish the basis for a highly flexible, multi-mission support capability that will be available to large numbers of NASA and other Government agency customers. Potential reimbursable class customers of the DAS include: NOAA; NSF; U.S. Navy/Army/Air Force; State Department; Justice Department; Energy Department and FEMA. The use of the DAS by the International Space Station (ISS) Early Communications system (ECOMM) is also feasible. Service reimbursement costs to NASA will be established as part of negotiated inter-agency MOAs.

DAS beamforming and demodulation components can be independently controlled by customers and will accommodate a broad range of new applications.

2.0 PROJECT OVERVIEW/DESCRIPTION

An approach to establish a basic operational DAS infrastructure would be followed. The basic DAS infrastructure would consist of control and monitoring functions for the intelligent/IF switches, IBUGs, demodulators, and data distribution systems. It is anticipated that a single fully populated COTS IBUG (six beamformers) would be procured as part of this project and the existing fully populated pre-production IBUG (developed as part of the TGBFS effort) would be incorporated into this DAS effort. Two fully populated demodulator groups would also be developed and procured. The end result would be the installation of an IBUG/Demodulator group at WSGT/STGT and an IBUG/Demodulator group at GRGT. It is expected that at the conclusion of the DAS effort, the demodulator groups will become COTS items.

The capability to procure additional beamformers and demodulators as COTS items after the end of the DAS installation effort would be coordinated and understood as part of the DAS effort. This approach lowers initial acquisition costs and will allow future expansion of the system to meet actual needs as they arise.

3.0 ORGANIZATION AND PROJECT MANAGER RESPONSIBILITIES

Mr. Thomas Gitlin is managing the DAS implementation. Mr. Gitlin is directly supported by Mr. David Zillig, of the GSFC Applied Engineering and Technology Directorate. Mr. Gitlin reports to the Space Network Project Manager (Code 451), Mr. Roger Flaherty, and to SOMO.

4.0 TECHNICAL AND SCHEDULE COMMITMENTS

Project Technical and Schedule Commitments			
Functions	**FY-00**	**FY-01**	**FY-02**
Design/Development			
Project Start	January 2000		
System Requirements Review (SRR)	June 2000		
Preliminary Design Review (PDR)	Sep 2000		
Critical Design Review (CDR)		Dec 2000	
Development Complete			Oct 2001
Operations Readiness			
Operations Readiness Review (ORR)			Jan 2002

5.0 RESOURCE COMMITMENTS

Project Cost Commitment				
Cost Categories	**FY-00**	**FY-01**	**FY-02**	**Total**
Manpower				
Contractor ($K)				
Civil Service (FTE)				
Material ($K)				
Other				
Contingency ($)	10% cost contingency is contained within the above estimates			
C of F (New Mods)	-	-	-	-
International Cost Commitment	-	-	-	-
Total				

6.0 OPERATIONS COSTS AND COSTS SAVINGS

Operation Service Center Costs		FY-02	FY-03	FY-04	FY-05	FY-06	TOTAL
AREA AFFECTED: MA SERVICE	PRIOR	-	-	-	-	-	-
	BUDGETED ($K)(1)	Δ=3.5 FTE [$340]	Δ=2 FTE [$319]	Δ=1.7 FTE [$236]	Δ=1.5 FTE [$207]	Δ=1.3 FTE [$183]	Δ=$1285
	REVENUE(2) ($K)	$1,315	$2,226	$3,541	$3,541	$3,541	$14,164
	SAVINGS(2)	-	-	-	-	-	-

(1) - FTE estimates are from the "CSOC Basis of Estimate - DAS System Recurring Costs" dated 2/16/00; cost information is from an email dated 28 Feb 00, Subject: FW: DAS PCD BOE and NTE from Mickey.Brunjes - cost information includes 20% contingency. Operational spares are included in the material costs in Section 5 of this PCD; specific sparing costs and expected spares lifecycles will be known after the DAS requirement/design phase evolves and a sparing analysis is performed.

(2) - Savings result from revenues offsetting operations costs. Revenue is anticipated from both reimbursable and future customers. Revenue estimates are based on current MA return link service rates and forecasted customer usage and duty factors. Revenue is computed as follows: Revenue = "Minimum per year" + (15% * ["Maximum per year" - "Minimum per year"]) with the maximum and minimum values as shown in the supplemental "Demand Access System (DAS) Business Considerations". To augment the DAS system as described in this PCD to allow support of the *projected* customers described in the "Demand Access System (DAS) Business Considerations" one COTS IBUG and one COTS demodulator group would be needed at an additional estimated cost of $680K - Please refer to the cost data for IBUGs and demodulators below and note that costs drop significantly if more than single units/groups are purchased. Assuming the DAS Business Consideration case revenues occur, system implementation and augmentation costs are more than fully covered after 3 years of operation.

IBU/IBUG Costs (based on current COTS price data)	**Price**
1 IBU	$70K
1 IBU with 19" Chassis, 2 Power Supplies, Control Processor, and 1 Fiber Channel Receive capability	$133K
1 IBUG (6 IBUs per IBUG)	$360K
2 to 4 IBUGs	$270K each
5 to 8 IBUGs	$220K each

Demodulator/Demodulator Group Costs (based on projected COTS prices)	**Price**
1 Demodulator (Demod)	$60K
1 Demod with 19" Chassis, 2 Power Supplies and Control Processor	$120K
1 Demod Group (7 Demods per Group)	$320K
2 to 4 Demod Groups	$250K each
5 to 8 Demod Groups	$200K each

7.0 PROJECT RISKS

The technical risk associated with development is relatively low. Prototyping has indicated that hardware and software systems can be built. Once the DAS architecture and requirements are established, the actual implementation will involve the integration of hardware and software, and the development of custom software for data buffering, formatting, transport, monitoring, and control.

8.0 EXTERNAL AND INTERNAL AGREEMENTS/DEPENDENCIES

Successful deployment of the Third Generation Beamforming System equipment is required since the EMCs and pre-production IBUG are needed for DAS. The TGBFS program is under contract and completion on schedule is highly probable with low risk. As of November 1999, TGBFS completion is expected in June 2000, well in advance of an expected need date for the equipment for DAS in early CY01.

IBUGs are being advertised as commercially available items (COTS) as of the writing of this PCD. It is expected that IBUGs would be procured as part of the DAS effort as commercial items with minimal risk.

Successful completion of the demodulator technology development currently underway under a technology development task is required to allow the use of the demodulators in DAS. Basic demodulators have been built for other applications; however, continued software and firmware development is necessary to provide demodulator control functions as well as the capability to process TDRSS MA return signals. The demodulator technology work should be complete by the second quarter of CY00 with relatively low risk.

An appropriate contractual vehicle will serve as the agreement between the implementation contractor and the Government. The work could be performed under the CSOC contract via a SODA task or a service development task. Additionally, an IDIQ type of contract could be utilized given the nature of the development required and the means by which system expansion is envisioned to occur. CSOC participation is expected in all phases of the DAS effort.

9.0 PCD ACTIVITIES LOG

PCD Activities Log						
Date	**Event**	**Change**	**Addendum**	**Cancellation Review Req'd.**	**P.M. Signature**	**Space Ops. Director's Signature**
	PCD INITIAL SUBMITTAL					

10.0 PERFORMANCE MEASUREMENT REQUIREMENTS

The DAS Product Manager will provide status reports on a monthly basis. These Monthly Status Reports (MSR) will include the following:

- A "fever chart" indicating high level status of key areas including schedule, cost and technical quality.
- A list of project highlights and issues, including descriptive statements, probable programmatic impacts, major actions and status updates of significant open problems and issues.
- A Gantt-style schedule chart.

11.0 SIGNATURES

<u>**SUBMITTED BY:**</u> | <u>**DATE**</u>

Original Signed By: | *2/22/00*

Roger J. Flaherty
GSFC Upgrades Manager

<u>**APPROVED BY:**</u>

Original Signed By: | *3/2/00*

Edward M. Burns
Mission and Data Services Upgrades Manager